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ABSTRACT

The shortage of qualified secondary school mathematics and science teachers is discussed and a program is described which aims to lessen the severity of this dilemma. The MidCareer Mathematics and Science Program (MCMS) at the Harvard Graduate School of Education demonstrates that quantitatively trained individuals with extensive knowledge of mathematical and scientific applications can provide an alternative supply of highly qualified classroom teachers. The program awards either a Master's degree or a Certificate of Advanced Study and secondary teaching credentials in the fields of mathematics, physics, chemistry, biology, and/or general science. Classes are conducted during the academic year with optional summer study workshops. The program has attracted individuals from diverse backgrounds and careers including a rear admiral, a public defender, a meteorologist, and several higher education professors. Profiles of the program's participants are given and the teacher characteristics of academic talent and entry motivation are discussed. The motives of the mid- or late career professional are also compared and contrasted with younger teacher candidates. (ML)

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REAR ADMIRALS AND BIOCHEMISTS:

WHY DO THEY WANT TO TEACH HIGH SCHOOL?

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The condition of American mathematics and science education at the secondary level has deteriorated significantly over the past twenty years. Both the numbers of students studying math and science and their achievement levels as measured by SAT's and the National Assessment of Educational Progress have declined steadily since the early sixties.(1) This disturbing situation occurred at a time when industry's need for qualified workers with math and science backgrounds -- from Ph.D-level senior scientists to high school educated technicians -- was on the rise. Moreover even those students who go on to non-technical careers often lack a minimum level of math and science competency required for non-quantitative jobs and daily living.

Federal commissions, state legislative task forces, private foundations and individual scholars investigating the sources of these downward trends all stress the critical importance of the classroom teacher in the delivery of a quality education. Findings generated by such studies indicate that the current math/science education crisis is due, in significant part, to:

1) A critical shortage of entry-level teachers certified in physics, math and chemistry; and

2) Significant attrition among experienced math and science teachers who are leaving education for higher paying jobs in industry.

The trickle of qualified secondary school math and science teachers entering and the flood of those leaving the profession have resulted in a frightening shortfall. In 1980, America's institutions of higher education produced 78% fewer math teachers and 64% fewer science teachers than they had in 1971. In 1981, 42 states (out of 46 responding to a privately conducted survey) reported either a "critical shortage" or a "shortage" of mathematics and physics teachers.(2) Since 1981, these shortages have worsened. For example, the 49 teacher training institutions in Massachusetts produced 2 teachers certified to teach physics in 1983.(3)

Economic, Social and Demographic Factors

The decline in entry-level mathematics and science teachers is the result of economic, social and demographic forces. Young, capable college graduates with scientific ability find that their aptitudes and training are far better compensated in industry than in education. Starting salaries in the computer or banking industries for technically trained individuals often rank between twenty-five and thirty thousand dollars, while in 1983, the mean starting salary for new teachers with Master's degrees

in Massachusetts was $15,400.(4) Not only are starting salaries much lower, but opportunities to reach a high salary level after lengthy service are non-existent in education. Thus, for example, the average maximum scheduled salary of public school teachers in Massachusetts in 1983 was $26,000.

Negative economic and social conditions are exacerbated by demographic changes that will heavily influence the future production of math and science teachers; over the next dozen years there will be more than a 25% drop in the number of 18-25 year olds.(5) Neither the pay differentials suggested by some to bridge the economic gap, nor the bills pending in Congress to forgive undergraduate student loans for the study of scientific education address the fact that the traditional labor pool for new teachers -- those in their early twenties -- will decrease significantly over the next decade. Moreover, women, who represented the "hidden subsidy" of the teaching profession now find abundant career opportunities in other fields. As a result, the trickle of new teachers entering the profession outlines the dimensions of a severe shortage.

The flood of experienced teachers to non-education fields is also economically and socially based. In 1981, almost five times more science and mathematics teachers left their school systems to take non-teaching jobs than left due to retirement.(6) And this trend promises to continue: a recent survey of mathematics and physics teachers in the Boston area indicated that within the next two years, six out of ten math teachers plan to leave teaching, while 13 out of 19 physics teachers hope to find other non-teaching positions.(7) In addition to the obvious economic advantages of such a career change, these professionals are making the move to industry because they believe that society does not value their contributions. Their beliefs are reinforced by low salries and the general societal attitude that teachers are involved in little more than sophisticated childcare. With over 50% of the math and science teacher workforce facing retirement in the next decade, the exodus will be immense. In fact, the U.S. Department of Education and the two national teacher associations predict a need for 1 million <u>new</u> teachers by 1990.(8)

In addition to a serious shortage of teachers, very few current or aspiring classroom teachers from traditional programs have experience in the applications of mathematics and science. They must rely on teachers' manuals and other commercial materials to convey the usefulness of the subject. While ample teacher in-service training opportunities were available for math and science teachers in the 1960's to update and develop their subject matter knowledge and skills, very few opportunities have been

recently available to teachers. As a result more than half of the current science teaching force has not attended an inservice workshop or professional meeting in the last 10 years.(9) In classrooms this weak link to realistic applications leaves most students with little sense of the relevance of the material or the excitement of the scientific method. Finding individuals who are experienced and knowledgeable in the use of mathematics and science has been difficult in the past.

The response of higher education institutions to these problems of diminished supply and lack of relevant experience of classroom teachers should not be to lower standards to attract more prospective teachers; the academic achievement levels of entering teachers are already among the lowest of the college graduates.(9.5) Nor will it be successful to attract individuals with subject matter expertise with little knowledge or training in the teaching of that subject. Research now confirms what most intuitively have known for years: knowing the subject matter does not guarantee a successful teacher.(10) Rather, institutions must identify a new source of high quality teachers whose knowledge of the subject matter and its applications as well as ample and directed training in pedagogy are among their greatest strengths.

The MidCareer Math and Science Program

Early experience with the MidCareer Math and Science Program at the Harvard Graduate School of Education suggests that individuals possessing these important skills and the willingness to enter the teaching profession do exist. Now in its second year of operation, the MidCareer Math and Science Program demonstrates that this new source of quantitatively trained individuals with extensive knowledge of mathematical and scientific applications can provide an alternative supply of highly qualified classroom teachers. The Program, which awards either a Master's degree or a Certificate of Advanced Study, is conducted during the academic year with optional summer study workshops. Some individuals choose to pursue the Program half time while changing from their former careers. All participants intend to undertake full-time classroom teaching upon completion of the program.

The quality and the number of individuals the MCMS Program attracts is impressive and surprising to some. The men and women participating in the Program's first two years have had diverse backgrounds and careers, including a retired rear admiral and army colonel, electrical, civil and mechanical engineers, biochemistry and microbiology specialists, physicists, photographic scientists, higher education professors of chemistry and physics, a public defender with an undergraduate degree in mathematics, a

missile system designer, a chief meteorologist from the U.S. Weather Service, statisticians and a veterinary technician. All of these participants and the vast majority of the over 625 individuals who have, since June 1984, expressed an interest in attending the program for the 1985-86 year have Masters or Doctoral degrees in the fields they intend to teach. The Program is approved by the Massachusetts Department of Education to award secondary teaching credentials in the fields of mathematics, physics, chemistry, biology and general science.

Mid career professionals are a particularly appropriate source of new teachers because many of the economic, social and demographic factors mentioned previously are not as constraining for this group. Many potential participants in the fifty to sixty year old bracket are eligible for early retirement or voluntary severance plans. Depending on the industry and the employee's status, good pension plans are also available to them. With the potential tax advantages and changing financial requirements, a new career in teaching may not be as economically constraining for a midcareer professional as it is for a young teacher.

The social argument that teaching is not a status-conferring career also bears less influence on midcareer professionals because many professionals have already established their reputations in another field. Recent research on career development indicates that many individuals in this age bracket have economically -- and psychologically -- "plateaued" in the corporate world and would welcome an opportunity for new challenges.(11) Teaching as a second or third career offers a change of pace and a new employment environment.

The demographic factors that will contribute to the trickle of young people entering teaching are also more favorable for the midcareer group. The group of 49-54 year olds will increase significantly in the next decade.(12) This factor, coupled with the increasing interest and legality of professionals to work beyond the age of 62 or 65, combined with increased early retirements makes the potential contribution of this midcareer group extremely large.

Other Models

The Graduate School of Education was attracted to this program design after considering and rejecting a number of alternative plans. For example, some suggest that recertification programs are an effective means to produce mathematics and science teachers. Designed to take individuals certified in nonscientific areas, these programs provide training in mathematics and science subjects, presuming that pedagogy is transferable from one subject

area and school level to an other. Within schools of education, however, resources typically do not exist to provide subject matter competence. In addition, recent State legislative and education department reforms have increased the subject matter competence to include specific subject matter topics, often exceeding the requirements for a Masters degree. Massachusetts, for example, with a reform of its requirements in 1982, now requires 36 semester hours of subject matter study within the field of certification. Specific course content is prescribed. For example in mathematics, Massachusetts teacher trainees must show evidence of coursework in algebra, geometry, trigonometry, calculus, number theory, probability statistics and computer mathematics.(14)

The MAT model, which produced many academically able teachers from the 1950's until the mid 1970's, now struggles with changes in its external environment. In particular, the age group that typically fueled the MAT engine, namely those in their early 20's, is currently shrinking. Within Massachusetts, the 18-25 year old age group will decline by 41% in the next ten years. Attracting candidates from this shrinking pool is further exacerbated by the costs of undergraduate and graduate education. Young undergraduates now leave college with significant financial debt which reduces the attraction of immediate enrollment in a one or two year graduate program at a private institution whose tuition may rival the undergraduate rate. Education programs suffer particularly in this regard because of the low salaries the profession offers after graduation.

Fewer and fewer undergraduates choose to enter profession schools immediately after graduation. Harvard College provides an example of this trend with regard to all professional education. In 1964, 83% of the senior class planned enrollment in professional programs the following September, while by 1984, only 40% of the graduating class had plans for immediate graduate work.(15) The financial requirements of graduate study and the declining numbers of students may make finding students for the traditional MAT programs extremely difficult.

Based on these and other considerations, the Graduate School of Education designed its mathematics and science teacher training effort with the mid-to-late career professional as its target group. This group is attractive because they address many of the concerns raised in other program designs. Namely, these individuals: exhibit strong enthusiasm, expertise, knowledge and interest in the subjects they will teach; possess extensive and current knowledge about the applications and usefulness of mathematics and science; represent a growing labor pool; and frequently have greater financial flexibility than younger professionals because the two most significant financial

expenses of their careers - mortgage payments and childrens' college tuitions - are often well along or behind them, making their cash flow requirements significantly less.

The existence of the MidCareer Math and Science Program and other similar models of mid/late career training programs present an interesting opportunity to explore two areas of common and current interest in the characteristics of the teacher workforce. These topics are the academic talent and the motivation of those entering the profession.

Academic Talent of Entering Teachers

Many researchers, public policy analysts, union officials and members of the general public express grave concern about the academic quality of those entering the teaching profession.(16) In fact, raising admission standards for teacher education programs currently is one of the most popular reform proposals for teacher education in the country.

Concern about academic quality of teachers has as its roots the fact that "The vast majority of new U.S. teachers in any field stood in the bottom third on measures of academic ability."(17) Equally disturbing is the finding that the least academically able are likely to stay in the profession while those with more academic ability leave after a short period of service.(18) While there has been some debate as to the relationship between teacher academic ability and student achievement, recent research now shows a modest relationship between the verbal ability of teachers and students' learning.(19) These findings give a research foundation to the clarion calls for higher entrance standards for the profession.

Through an examination of student applications to the MidCareer Math and Science Program from 1983 to 1985, it is clear that the MCMS program attracts teacher trainees who do not reflect the academic profile of others intending to enter teaching. Indeed, these candidates present extraordinarily strong academic credentials. Applicants to the Harvard Graduate School of Education are given the option of taking the Graduate Record Examinations or the Miller Analogy Test. On the Graduate Record Examination, applicants from 1983 to 1985 for the MidCareer Math and Science Program had a mean verbal score of 618 and a mean quantitative score of 634. Based on data provided by the Graduate Record Examination Board about test takers intending to enroll in education (including teacher training) programs, these results respectively fall in the 95th and 91st percentiles nationally. On the Miller Analogy Test, MCMS applicants produced an average score of 72. This statistic ranks these students considerably higher than the 50th percentile score of 47 which is given nationally for

students intending to enter education. With respect to academic talent, teacher candidates in the MidCareer Math and Science Program represent individuals who, unlike their counterparts in other "traditional" programs, are academically outstanding. Their academic excellence may in part be explained by an observation of Lortie: "Teaching is somewhat special in that those who enter it as a second choice possess above-average educational qualifications. In that sense, teaching has an enviable competitive position; its accessibility fosters the entrance of people who might never have gone to college to become teachers."(20)

Motivations to Enter Teaching

The most common question raised about a mid career teacher training program is what motivates individuals to make the career change to teaching. Certainly extrinsic rewards, such as financial remuneration or personal power, are not readily available in teaching.

Research on the factors that influence an individual's decision to teach has a long and rich history. Although motivations sometimes depend on external exigences such as the teacher shortages of the 1960's and 1980's or the surpluses of the 1970's, certain common themes seem to emerge from a variety of studies over the last 30 years. For example, the influence of former teachers has always been a strong factor, both in times of surplus and shortage.(21) Another common motive relates to the nature of the work -- either working with people they enjoy or doing work that they find enjoyable.(22) Personal or self-fulfilling motivations defines another set of motivations. Altruism and the serving or giving to others has been frequently cited as a major reason for entering teaching.(22)

While most of the research on motivations to enter teaching concentrates on individuals making their first career choices, examination of mid career changers to the teaching profession presents an interesting variation. Midcareer changers are <u>not</u> typically selecting the career because of blocked aspirations, parental prohibitions, economic or social advantages, as may be the case for younger candidates. Even the once popular notion of selecting teaching for its job security, seems to no longer play a strong role. In fact, with declining enrollments and Reduction In Force (RIF) measures in many communities defined by seniority, job security is certainly not assured for these newcommers.

By examining the personal statements required for application to the Harvard Graduate School of Education and the writing of MCMS program participants, a qualitative profile of motivations for mid career teaching candidates

is being developed. Four motivations have emerged: The need to engage in a "worthwhile activity"; a notion of service to others; personal style; and a love of the subject. Some of these motives are similar to those identified in prior research while others represent a divergence from previous study.

One common motivation is to engage in work that is deemed "worthwhile" by the individual. Candidates suggest that their view or definition of "worthwhile" has changed while working in their former careers and that they no longer derive a sense of satisfaction from their work. For example, one candidate stressed her changing view by noting "I have also recognized an increasing desire within myself to 'do something directly useful' to benefit people."(24) Another midcareer professional articulated the same change in personal feelings about worthwhile work:

> "I have reached a point where it is difficult to reconcile job security with my own personal values. It would be easy to remain in my present job: I like my co-workers, I feel needed, I enjoy the problem solving and the job pays well. These factors, however, no longer seem enough. I would like to apply my talents to an activity that I consider worthwhile. I have always enjoyed math and I suspect that I have the potential to be a good teacher."(25)

Altruism and the desire to pass knowledge along to others is another extremely common motive. Many candidates offer this reason within the context of repaying a "debt." As an example of this, one candidate suggests "I would like the opportunity to put back into the system that education which I was priveledged to take out as a young person"(26) Others want to make education as enjoyable for others as it was for them: "I want to do what I can to help children enjoy their school years as much as I enjoyed mine"(27)

Within the motivation to give, many of these professionals want to pass along scientific knowledge. The object they feel they will give is concrete knowledge, not philosophic orientations, political views or the perspective of their maturity. For some, teaching may be defined as the act of passing along discrete packages of information or thought processes. A Ph.D. engineer, reflecting about his motives to enter teaching stated,

> "I've acquired all this knowledge and I'm looking for an opportunity to pass it along. It's not that I don't feel

> good about engineering. But I think I'd feel better if I had a chance to pass this along to some students."(28)

Another scientist suggested "My longtime experience in 'real world' operational meteorology would serve as a large pool of scientific knowledge from which eager students could tap."(29)

Professionals also identify themselves with the older generation and express a desire to empower younger individuals. References to the "next generation" or "to do what I can during my short stay on this earth" are frequent. Reflecting both this larger perspective and the importance of a body of scientific knowledge, a civil engineer observed: "I have received a great deal of knowledge which I feel would provide a solid basis for instructing a suceeding generation to me."(30) Another candidate, presenting his motives for a shift to teaching, wrote,

> "I do this because in the last analysis, I have learned something about myself: that the pursuit of money and power has never been my goal; and that self-respect and the certain knowledge that I can contribute something worthwhile to society during my short stay here on earth are my primary concerns."(31)

Other candidates express a concern about "quality of life" factors. Some note that business travel, competition and the nature of the work with computers or other inanimate objects is no longer fulfilling. Although frequently expressed in interviews, one candidate wrote, "The involvement with people is an important factor to me because a good proportion of my time in the past few years has been occupied in dealing with objects: engineering drawings and specifications, investigations and reports."(32) No candidate suggests that teaching is an easy job; their respect for the profession is immense. But they do perceive that the quality of life and opportunities for personal satisfaction will be much greater in teaching than in their previous careers.

Finally, midcareer professionals often articulate a view of the teaching profession that will enable them to combine a fondness for the subject matter with a personal preference for working with people. While previous research on teachers has identified the desire to work with people as a central motivating force(33), the combination of a fondness for the subject matter along with this desire to work with people presents a different profile for these teacher candidates. A statistician in the MCMS Program wants to enter the teaching profession because "...over the

years I have developed interpersonal and mathematical skills and teaching will enable me to combine both of these."(34) The motives of a marine biologist suggest the same combination: "With my love of science and my ability to work with people, I can help students develop an understanding and appreciation of science."(35) A retired military officer who had experience tutoring in urban schools provides another example: "It is from this experience of helping young people and having an interest in math that I became interested in teaching."(36)

Thus, while many of the motives of the mid or late career professional are similar to younger teacher candidates, interesting differences appear to emerge. First, these individuals express an interest and fondness in the subject matter they will teach and perceive that teaching will enable them to continue their association with the intellectual content of the field. Second, many candidates articulate a clear perception that teaching is a process which transmits a specific body of technical, in this case, scientific knowledge. Finally, making a contribution to the next generation motivates many of these individuals. They are ready to share and see their work as providing a foundation from which others may build.

Future Research

Study of the Midcareer Math and Science Program and those attracted to teaching as a second or third career has only begun. Future research efforts will address the important question of how the perceptions of those entering the program will be changed after induction into the profession. Other questions focusing on the content and process of the training program will be studied as the result of current research. Perhaps by studying a "not-so-traditional" population, more will be learned about the teacher education process and the profession.